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LEAN STARTUP FOR CONTINUOUS PROCESS IMPROVEMENT, IN THE MANUFACTURING SECTOR

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ABSTRACT

Most manufacturers run businesses to be able to fulfill short delivery times, frequent shipments, various products, and price reductions. For this reason, the performance of the organization must improve and identify by conducting a process of innovation and product development (IPD). Process performance improvement is used to create a competitiveness and long-term survival of the organization. One approach to improve the organizational performance is the use of Continuous Improvement (CI) philosophy. For this reason, long-term organizational health depends on its commitment to do CI. Many previous studies focused on the performance from the success of sustainable process improvement practices. Much indication implies that lean tools and methods have supported manufacturing organizations to improve their operations process. The real effect is in the area and the difference in an operational performance like cycle time, speed, quality, cost, customer loyalty, and responsiveness. Systematically able to identify the manufacturing wastes and create a lean culture within the organization. Therefore, this study gives a starting point for separating lean initiatives for quality improvement (QI) throughout the organization.

***KEYWORDS:** Organizational Performance, Innovation and Product Development, Continuous Improvement, Wastes, Lean & Quality Improvement*

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Original Article

1. INTRODUCTION

The effectiveness of the process for innovation and product development (IPD) is important for competitiveness. For this reason, new products introduced to the market are important factors to build competitiveness and long-term organizational survival [1] T. M. Yeh, (et al). In the competitive environment needs to utilize the power of the organization must work to find and fix the vulnerability. Other IPD activities support the production process such as product releases, activation and termination of products on the market; all of these activities make the process more complex. The economic crisis shows that important to focus on cost reductions. Hiding problems on the production line is not the right way to provide solutions; need to find the root cause of the problem of production. Management must focus on the ways to solve the problems. Unfortunately, CI programs often issue IPDs, because of the complex characteristics inherent in the process, as well as the amount of information needed, and the difficulty of decisions. Many companies exclusively dedicate their efforts and time to improve the manufacturing process rather than focusing on increasing IPD. And even companies that build CI to improve organizational performance are more successful in the operational field [2] A. M. Khan (et al). Lean manufacturing has been a recognized company and a key to raise competitive advantage for manufacturing organizations. Most industries use and integrate basic lean tools and techniques at the starting phase to improve the program such as current mapping process, using 5S, standardized work, etc. After implementing, hereafter will think about non-value added activities. Some activities

are wasteful. Every activity takes some time and cost. Therefore, these activities should be reduced even whenever possible to be eliminated from the system. The waste elimination will relate to the methodology of lean. The lean approach is intended to identify the non-value added activities, whose existence is among value-added activities. The lean methodology has a strong drive to improve the processes and focus on the flow of operations. Lean methodologies have a powerful push for continuous improvement and focus on the flow operating processes [3]H. Soriano-Meier.

Lean manufacturing (LM) provides a new approach for the management; especially the old companies and its organization are managed based on the traditional push system. The results of the improvement process can be extremely dramatic with the always improving cycle time, quality, and customer satisfaction. Lean manufacturing does not only consist of a set of tools and techniques. Lean manufacturing is a way to improve the process. That means, lean manufacturing is a set of powerful tools and techniques when combined and matured with the culture of the organization, it will be able to reduce and then eliminate waste [4] A. T. Nahm (et al.). Lean manufacturing is an integrated system consists of very complicated information in a variety of management practices, including just in time, quality systems, work teams, and cellular manufacturing. The companies have a golden opportunity to be able to reduce cycle time, customer lead-time and costs, increase productivity, employee empowerment and improve quality, through the implementation of Lean Manufacturing methodology. The Lean Manufacturing method involves all employees and make major changes in attitudes and embedded in all individuals who can change the organization towards better[5] R. Shah and P. T. Ward.

To further, strengthen the process of identifying a problem, then the statistical methodology is used as a sturdy bridge. The next development is a set of tools and techniques of six-sigma is used to offer a powerful solution to the problem of the industries. Lately, both methodologies are integrated to get more powerful. On the one hand, a lean methodology is used to eliminate waste and non-value added activity, while the six sigma methodology with all the tools and techniques is used by the organizations to improve the performance processes and capability.

2. STUDY LITRATURE

Companies around the world face new challenges day by day; globalization causes increased competition and eliminates commercial distance. Recently, there has been an evolution and a market paradigm shift, breaking the old paradigm. Initially, the manufacturer determines the selling price, and now, the market and/or customer is the one who determines the price; so, the market demands faster response times, higher quality, and better production flexibility. The business world shifts and the resources management paradigm also changes. This is a different business perspective, and to understand it needs to follow the changes that occur to stay competitive. It should understand that the cost is not just a calculation of the real things like the amount of material, salary, electricity, etc. Several hidden costs that must be identified and then avoided even reduced by the company. Examples of hidden costs are downtime, poor quality, scrap, low efficiency, over time, etc. All of these costs are waste, and the Continuous Improvement (CI) process aims to reduce, even eliminate the waste.

Research topics on continuous improvement are not new. CI is a process that aims to optimize the physical flow, products, and information, to be able to control quality and production costs [6] T. Maudgalya(et al); Quality improvement methods focus on reducing defects and errors by eliminating variations in manufacturing and service operations [7]J. Jacobsen. The term Continuous Improvement is linked to various organizational developments, including total quality management (TQM), waste reduction campaigns and customer service initiatives, application of "lean manufacturing" techniques, employee engagement programs [8] S. Caffyn. [9] M. Colledani(et al.),[10] N. Bhuiyan, and A. Baghel, who

define continuous improvement as "a culture of sustainable improvement". [11] D. Maletic(et al.), [12] G. D. Putnik, have discussed the subject of continuous improvement, in detail. Continuous improvement is "a weapon to maintain and enhance competitiveness", a more practical use of sustainable improvement, and as a "tool for implementing production systems such as TQM or Lean" [13] J. A. Marin-Garcia (et al.). Various quality improvement techniques continually encourage behavior that embodies learning, knowledge creation, and further supports the organization's efforts to increase the productivity and quality. Lean is generally associated with the methods to eliminate waste. Lean production is an integrated socio-technical system which aims to eliminate waste by reducing or minimizing suppliers, customers, and internal variability [14] R. Shah, and P. T. Ward. The lean focus is the elimination of waste, and improving process flow, using proven methods. There are indications, 5S, VSM, standardized work, Kanban, and poka-yoke have successfully applied by many organizations. This happens because the method is relatively simple, requires minimal resources (ie, time, material, etc.) and low costs for implementation. Besides, the definition of CI is a process of improvement, which is systemic, supported and enhanced by management, towards a positive direction, with various tools that do not require large investments. Various continuous improvement methodologies developed by the Toyota Production System (TPS), finally use as the basis for the term Lean Manufacturing to increase the performance. The empirical nature of the use of the continuous improvement methods will increase the understanding of the improvement techniques used in the organization. Identification of tools that were successfully implemented, and considered effective, used as a starting point for quality improvement initiatives by the organization.

Table 1: Continuous Improvement Technique

lean methods	quality tools	
	7 old tools	7 new tools
1 v5-S	1 flowchart	1 tree diagram
2 value stream mapping	2 histogram	2 affinity diagram
3 SMED	3 check sheets	3 interrelationship diagram
4 standartdized work	4 scatter diagram	4 matrix diagram
5 error proofing)poka-yoke)	5 pareto chart	5 process decision charts
6 workload	6 control chart	6 activity network diagram
7 kanban	7 fishbone daigram	7 prioritization matrices

In addition to the TPS and Lean methods, in the 1980s, Motorola introduced a continuous improvement methodology, with the term 6-sigma. It focused on using statistical methods to improve control, minimize defects, and improve process performance. A continuous improvement (CI) strategy is a way to reduce waste by focusing on small changes. CI is associated with a progressive improvement, without the need for large investments [15]J. Singh, and H. Singh. The term "continuous improvement" is synonymous with the term "Kaizen" which is used as a tool for continuous improvement [16]P. Found (et al.). Finally, Kaplan and Norton in the early 1990s developed a method of continuous improvement, namely the "Balanced Score Card (BSC)" method. But the BSC is more dissemination of strategies, measurement systems, and communication tools, rather than methodologies for continuous improvement. The term "continuous improvement" begins its direction, with various methodologies that have been developed, including TQM, Kaizen, MBNQA, Lean, Agile, Six-Sigma, Business Score Cards, and others as well as how to relate to one another; but at the same time, it loses its purpose and simplicity. It is noted that variations are always inherent in each process, while the quality improvement methods provide tools, to reduce variation and solve problems. Some techniques for reducing variation are a creation of ideas, organizational tools, and methods of data analysis, monitoring, and process control [17]A.

Alvo-mora (et al.). Often use tools such as PDCA, TQM, or Six Sigma methodologies, to guide continuous improvement efforts in an organization [18] J. V. Chovach (et al.).

2.1. Lean Concept

Usually, the companies identify problems by mapping process along the stream. This is important because, with the mapping process, it knows which processes have wasteful activities. Lean Manufacturing started from the Toyota Production System (TPS), which began and developed by Toyoda Motor Car Company (now Toyota). During its development, Toyota started producing machines, trucks, small delivery vehicles, and cars. Lean manufacturing is not new in the automotive industry environment. This concept has been the sudden success after Toyota in the 1980s through the big three (Ford, General Motors, and Chrysler) and other Automobile industry. [19]H. D. Wan and F. F. Chen refer to the level of leanness to gain a level of performance along with the value stream. Lean production will occur if with minimal waste, due to reduced operation is not required; the operation efficient, or not an excess buffer in operation. [20] H. S. Meiner and S. F. Paul identified nine variables of leanness, namely, zero defects, elimination of waste, continuous improvement, JIT delivery, decentralization, multifunctional teams, integrated functions, and vertical information system. This mean can provide practical implications for managers to use lean tools to measure the degree of commitment to lean production through TQM and JIT. Lean approach is intended to identify the non-value-added activities which are among the value-added activities. Lean methodologies have a powerful push for improvement and focus on flow operating processes. However, the implementation of lean faces many obstacles such as lack of support, commitment from management, employee attitudes, lack of communication, and much more to be identified. It also indicates that the implementation and success factors of lean are not only caused by the technical aspects but also integrated with the non-technical aspects.

A mapping is required along with the process stream and identified the flow processes that do not lean; the mapping process is called Value Stream Mapping (VSM). This mapping process will be very close to the requirements and voices of consumers. VSM is a mapping method to identify the non-value-added activities along the process. To obtain a current state map, it is necessary to identify the root causes of problems and gather information. When building VSM, it usually forgets about the identity and value of the customer. These customer requirements are often ignored, thus making VSM lose momentum and energy to search for its non-value-added.

[21] K. L. Sim and B. Chiang found that for the sustainability of the organization in the future, manufacturers need to re-evaluate the manufacturing and business practices in the best way to adopt a philosophy of Lean manufacturing-LM. Now, LM is widely accepted as a part of the company's strategy to achieve the performance excellence [22] M. S. Umar (et al.) and help companies enhance the business performance and competitiveness advantages using the 5-why method[23]K. Demeter (et al.).

The benefits of LM implementation are not only for sector manufacturing but also for the service sector. Lean manufacturing helps organizations to increase the operational performance [24]G. Nawanir (et al.), manufacturing performance [25] K. O. Cua (et al.), business performance [26] M. Ga (et al.) and quality of performance [27]S. Gupta, and S. K. Jain. By considering their potential to improve the operational performance, the application of LM will benefit the industry. [28] J. Womack and D. T. Jones describe that the Lean manufacturing requires not only the technical questions that must be fully understood, but also the relationship between the manufacturing and other areas of the company should be examined in depth. Furthermore, other industries began implementing the LM to gain profit as seen in Toyota. Lean

Manufacturing methods involve all employees and make changes which embedded in the attitude of all individual that will change organization better.

2.2. Lean Six Sigma- LSS

Six-sigma management strategies require improvements through the process of problem identification, root causes, process redesign and reengineering, and process management. Six-sigma follows a model known as phase DMAIC (Define, Measure, Analyze, Improve, and Control). Hence, Six Sigma will start with analyzing the defects. Meanwhile, lean to have an initial focus on customer requirements, process flows, and identification of waste [29] R. D. Snee. Therefore, implementing both Six Sigma and Lean with set-tool has an improvement results were far better than if only use one method [30] S. K. Bhim Singh (et al.); [31] V. Kumar. Now-a-days, lean has been integrated with Six Sigma and has helped many organizations to reach a continuous improvement processes and better savings associated with the activities, operations, and quality costs. Many companies and industries have recognized that there are strong synergies that resulted when both initiatives are combined [32] N. F. Habidin (et al.).

Lean Six Sigma (LSS) is a combination of two powerful methodologies improvements for businesses and organizations, that focus on operational excellence to always search for a better improvement, in terms of speed of the process saving the cost of quality, customer satisfaction, and ultimately to a competitive advantage. LSS is the newest of managerial practices that can assist in creating value by eliminating waste along with the process flow, eliminate the causes of defects in the product. LSS excellences such as reducing defects, eliminate waste, improve quality by minimizing process variation.[33]V. Kumar (et al.) indicating that the LSS is an advantage in business improvement initiatives to overcome the challenges of current production.

Since lean can identify and eliminate the defect with the use DMAIC cycle, Six Sigma is a method used for measuring and determining the capability of a process. On the flip side, Six Sigma aims for identifying and eliminates defects but do not consider how to optimize the process flow. Therefore, implementing Six Sigma and Lean with application tools set can improve and results far better than what achieved with only one method. The role of the supplier in providing input for the production process is extremely important in designing value, along the production process. Availability of materials from the suppliers is an entrance to know the variance. Each supplier will be judged based on quality. Organizations provide training and technical assistance to the suppliers to know the needs of production [34]X. Zu (et al.). If selecting suppliers based on the quality, the company indirectly will encourage suppliers to continuously improve the quality of the product or service to each customer's requirements. This concept will result in a change in culture, and encourages continuous quality improvement, and can help to reduce the variability of the component or part [25] K. O. Cua (et al.). Improvement of leadership in the group will be able to sustain and improve the application of LSS [34]X. Zu (et al.). The structure of the LSS may assist companies in recruit employees. For completing a quality improvement program requires statistical process control along with the DMAIC methodology used for problem-solving. This concept can be done by developing leadership skills and providing practical training to increase the lean operation. Moreover, the use or implementation of continuous improvement regarded as a leadership development tool [29] R. D. Snee. The leadership role in changing the organizational culture can affect and assist the company in defining the gap and suggest new ideas for improvement [35]C. Delgado (et al.).

[36] K. W. Linderman (et al.) indicates that the Six Sigma is applied to the business commerce, executive management, the production process of manufacturing goods and services. Most applications are recently included in

improving operational safety [37], improve the quality of surveillance camera to reduce excess costs [38], the implementation of lean manufacturing in the food and drink industry [39], enhance customer loyalty to the Bank of America and Citigroup [40], reducing the waiting time and length of stay of patients [41], reduce the length of stay for Eye Surgery (Matthew, 2013), reducing waste and the lead time ([42], improve staff satisfaction [43].

3. METHODOLOGY

Many companies succeed in implementing LSS that focuses on process performance. The results are reduced costs, increased quality and production time. In this paper, the LSS methodology is applied to manufacturing companies, especially on local bicycle products. The main objective is to increase production, minimize waste, to reduce defects and costs. This section explains the methodology used for case studies. Research for development and improvement system of existing conditions will begin with the creation of structures and plans. The form is, questions to be answered by the respondent D. R. Cooper and P. S. Schindler [44]. To facilitate and simplify obtaining the data, the process survey, for the selection of critical waste is based on the answers of management and employees who understand the problems of production and academia. The survey instrument used in this study is using a seven-point Likert scale, representing the various perceptions of very low (1) to very high (7).

This methodology is divided into four main parts; consisting of problem identification, literature, case study design, and data analysis. In this paper, a bicycle company is a case study. Research begins by identifying the problems in the production process and ends with creating solutions for process improvement. Based on the data available processes, research began by studying the flow of the process, with the VSM models and devises a plan to determine and explain the details of the problem. Two tools are used to complement the completion of its manufacturing problem, is a six-sigma-phase DMAIC used as a general framework for process improvement and lean tools in each phase. Furthermore, research focuses on employee involvement and motivation were used to change the new culture [45] M. Hook, and L. Stehn.

With good and true interviews, all types of waste can be found, and finally eliminated, and production process can be managed more effectively. Questionnaires were distributed and reviewed by experts of both parties – namely, LSS academia and industry to examine the content. A team who came from various divisions, with the support and involve everyone, at all levels of an organization, could achieve maximum gains. Questionnaires can be modified based on comments from experts LSS. A preliminary study conducted to determine the clarity of meaning and a term commonly used in the industry, the relevance and clarity of questions, the time required to complete the entire questionnaire, and test validation and reliability of the whole question ([46] B. B. Flynn (et al.); [47]Y. Su, and C. Yang). Furthermore, interviews conducted with all supervisors and managers, namely process, maintenance, quality, and operation, to obtain complete information.

4. CASE STUDY AND RESULTS

The case study was taken where the manufacturing control process improved by implementing lean six sigma-LSS methodologies. The manufacturer of the bicycle is the place conducted research. Based on the identification of the activity [48]P. Hines and D. Taylor, the types of activities are classified into three types, value-added (VA), necessary but non-value-added (NNVA), and non-value added (NVA). Waste was joined and eliminated by reducing the downtime with the implement of change of working process while reducing the variation along the business process as simultaneously. The LSS steps with a systematic approach, begun from the current state, defining realistic targets to achieve the ideal

conditions, preparing a process map to identify the inefficiencies and waste, and implementing corrective actions [49] J. M. Kumar (et al.).

The case study is selected based on the idea of theoretical sampling. In this case, theoretical sampling is preferable. The questionnaire survey is designed and helped in the understanding of six-sigma in an organization. The next steps are to conduct in-depth case study. A case study helps in developing a theory that has more reasons, more generalizable, and more specific [50] K. M. Eisenhardt and M. E. Graebner.

As seen that the bike identified the activities that occur along the flow production process. From a long process and overall activities known that in the flow along the production process, there is 23.3% value adding activity, 35.19% is necessary and 43.52% is non-value adding activity. This percentage shows that the waste in the production process flow still exists. Therefore, the non-value-added activity must be identified more depth to know the type of waste that is hidden and does not appear on the surface. Non-value-adding activity is an activity that causes waste. This activity as much as possible to reduce even eliminates. Meanwhile, a lot of non-value-adding activities even do not see and difficult to monitor are along the process. There are seven commonly accepted wastes in Toyota Production System-TPS [51]P. Hines, and N. Rich such as (1) overproduction, (2) waiting, (3) transportation, (4) inappropriate processing, (5) unnecessary inventory, (6) unnecessary motion and (7) defects. The identification process of the wastes can give an overview that there is a process that causes defects. The two main processes that cause defects are the welding process and the painting process.

Table 2: Types of Wastes and Ranking

no.	types of waste	score									total	rankin
		1	2	3	4	5	6	7	8	9		
1	over production					1	1	2	2		13	7
2	waiting		1	1	2	2					31	3
3	transportation						2	4			14	6
4	inappropriate processing	1	1	2		2					35	2
5	unnecessary inventory					2	2	1	1		17	5
6	unnecessary motion				1	2	3				22	4
7	defects	1	2	2	1						39	1
	weighted	8	7	6	5	4	3	2	1	0		

Furthermore, the search for the causes of defects is only in the two main processes, namely welding and painting.

By using root causes analysis (RCA), both welding and painting, then a search for the causes of defects can be found. Following is shown the RCA search for the welding process and process of painting Roots cause above shows the causes of undesirable process, which leads to waste. This method is a simple way to determine the critical foundations of many causes that do not appear. Based on the root causes it can be generated a few alternatives solutions. The table below shows a few alternative solutions base on the RCA of the welding process and process of painting.

Table 3: RCA in Welding Process

process	waste	sub waste	why 1	why 2	why 3	why 4
welding	Over processing	a lot of rework	mostly found defects on the frame	Many materials are damaged when it moved	Material handling usage that is not appropriate	the operator does not comply with operating procedure

Table 4: RCA in Painting Process

process	waste	sub waste	why 1	why 2	why 3	why 4
painting	defect	the results of the paint melts	Distance of painting is too close	Setting of the spray gun and discs do not conform	the operators does not comply with operating procedure	skill and operator accuracy is lacking
		the results of the paint and polish the rough	a dust coming in and attached to the frame	contained dust on the floor and the machine	floor and machinery were rarely cleaned	the operator does not care about the cleanliness
		a shortage of paint on the frame	contained a few parts that passes from the painting	conveyor rapid and later than the painting	control operator imprecise	

Table 5: Root Causes and Improvement Alternatives

root cause	improvement alternatives
the operator does not follow the SOP	designing a new System Operating Procedure-SOP for improvements
the operator is not conscientious and lack skills	the operator training to increase skills especially in welding and painting
	the training to increase the product quality control

The proposed alternatives based on the RCA can be used as a stepping of management to take a position on quality improvement. It is becoming a main driving force to improve the technology. Factors influencing a successful lean six-sigma projects include management involvement and organization commitment, project management and control skill, continuous training, and culture change. This method makes it possible to provide a better support for designing strategies, leadership, and increasing the requirement for mentoring, training and coaching. The most flexible CI in a corporate environment is lean six sigma methodology. Training for the corrective action is based on identification, definitions of CI goals, and prioritization of improvement projects. Some essential characteristics possessed by the CI program are everyone involved in the organization is a team. The continuous learning process, always looking for new opportunities, accepting ideas wherever they come from, and empowering everyone to make improvements.

5. CONCLUSIONS

The CI program by implementing the lean six-sigma is proven and successful in increasing organizational performance. These are the main strengths and drivers of continuous process improvement. Factors affecting the success of lean six-sigma projects include culture change, management involvement and organization commitment, continuous training, and project management and control skill. Key indicators and weakness of six-sigma give opportunities for implementation of the lean six sigma project. It enables better support for strategic, direction, and improving requirements for mentoring, training and coaching.

This paper presents the lean six sigma methodology to improve the performance in the company of the manufacture of bicycles. The scope of the research began of identifying, analyzing the problem by minimizing all kinds of waste and increase the value of sigma based on customer requirements and the ability of management to improvement. The results from the application of LSS can reveal various causes of our problems, and increase the level of production, reduction of waste and minimize production costs. The development and sustainability of the lean six-sigma framework are that six-sigma to reduce variation and lean is to reduce cycle time. This article presents the application of lean methodology to startup eliminating waste throughout the process and six sigma to startup to reduce flawed changes and increase sigma levels. By focusing on customers, and systematically able to translate quality characteristics into

improvement projects, so organizational benefit is achieved. It stated that lean six-sigma programs enable an organization to become more creative through a dual focus on efficiency and continuous improvement (CI).

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